ANIMAL LIFE OF THE GANGES.

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The study of the animal life of the Ganges is no new thing. For many centuries it has attracted the attention of rulers, of religious leaders and of naturalists, who have regarded the matter from a practical, a superstitious or an intellectual point of view. Even in a strictly scientific sense it dawned in Bengal before the beginning of the 19th century. Apart from casual mention of a few real and mythical animals, the earliest document we possess is the Fifth Pillar Edict of Asoka[1] by which game laws and fishery legislation were instituted in northern India in the 3rd century B.C. In this inscription the Emperor Asoka had carved on enduring stone a list of birds, beasts, fishes and possibly even insects which were to be strictly preserved from slaughter, and he decreed that no fish of any kind should be caught or sold on fast days throughout the year or for three days at four full moons in each year.

Unfortunately the names of aquatic animals in his list of protected species are very obscure. To judge, however, from modern Bengali two names have preserved their meaning for all these centuries and are still in use in a modified form. They are those of the Sting-rays (of which two species are common in the Ganges)[2] and of a common river tortoise or terrapin now known to science as *Kachuga donghoka*.[3] Possibly Asoka also included the Gangetic Porpoise in his list, for the word *gangapuputakas*, which has puzzled the commentators, may be partly onomatopœic, representing the noise made by the animal as it expels its breath on the surface.

Asoka's motive was neither economic nor scientific. He was an ardent Buddhist reformer interested in animals as partaking of life and thus being in the stream of transmigration. We do not know why he considered certain species more important than others from this point of view: perhaps because their names were mentioned in ancient legends current in his time and already adopted into Buddhism. Perhaps, on the other hand, their flesh or some other product of them was regarded as a luxury and not as a necessity of life.

After about seventeen centuries another emperor appeared in Hindustan who was a real naturalist—Babur, the first of the Moghuls. Babur is one of the most human characters in Indian history, in which he lives as few others live because of the intimate personal memoirs he left behind him. These included not only an account of his own adventurous and momentous life but also a description of India and its natural products—the first Imperial Gazetteer. Amongst many practical and intellectual activities Babur, who was probably in a sense illiterate, was a keen botanist. The only two things he admired in India were

1. For the latest translation of this edict see Vincent A. Smith, *Asoka* in the "Rulers of India" series, p. 204 (Oxford: 1920).

2. Asoka's name, which is translated "(?) skate" by Smith, is *samkujamachi* a compound word in which the last two syllables of course mean fish. The equivalent for the first two syllables in Sanscrit and modern Bengali is *sankar*, which is said to mean 'bastard' or 'mongrel,' *i.e.*, between a fish and a tortoise. See Chaudhuri, *Journ. As. Soc. Bengal* VII, p. 627 (1912).

3. Asoka called it *dadi* or *dudi* and the name is translated 'female tortoises' by Smith. The modern Bengali is *dundi*, *dudr* or *dhoor*. The flesh of this tortoise can be eaten even by Brahmins. See Chaudhuri, *Rec. Ind. Mus.* VII, p. 212 (1912), and Haraprasad Shastri, *Journ. As. Soc. Bengal* X, p. 137 (1914).

the wealth of the country and the red Hibiscus flower, but he took an interest in its animals also. He was the first to describe a peculiar habit of the commonest of our north Indian frogs (*Rana cyanophlyctis*), which skips lightly along the surface of the water when disturbed.[1] He gave also a description of the Gangetic Porpoise, evidently from his own observation, and of the crocodiles of the river, all of which must have seemed strange and unnatural beasts to a man from central Asia. After Babur more than two centuries were to elapse before the animals of the Ganges were first studied in a scientific spirit.

The initiation of this new work was due to a Scotchman, but he was by no means the first European naturalist who wrote on the fauna of the river. To the Greeks and the Romans[2] India was a land of marvels. Herodotus, the Father of History, remarked in his sober way some twenty three centuries ago, how strange it was that the uttermost parts of the earth produced the most admirable products. He gave as an instance the supposed fact that the animals of India, except the horse, were larger than those found elsewhere.[3] Later writers greatly improved on this. They talked of eels 300 feet in length, of the monstrous turtles of the Ganges and of a sky-blue worm 60 cubits long and armed with a pair of tusks (or gills) by means of which it seized the elephants which came to drink at the river's edge. The elder Pliny, who lived in the 1st century A. D. quoted this story of the elephant-eating worm with some reserve, but also gave an account, only exaggerated in point of size, of the Gangetic Porpoise, which he called by the modern generic name *Platanista*. Further, he recorded the fact that certain fish of the Ganges migrate overland to breed in isolated pools. To this point I will return later. After Pliny the next writer of importance on the Gangetic animals was Aelian, who wrote in Greek about a century later. He added little, except a fairly accurate description of the Gharial. Neither Pliny nor Aelian had visited India: they relied on travellers' tales. We need not follow out the history of the myths they transmitted, but may note in passing that for once Sir John Maundeville, the notorious liar of the Middle Ages, was more moderate and reduced the length of the Indian eels from 300 feet to "30 foote or more."

To come to modern zoology, Dr. Francis Buchanan, the Scotchman to whom I have already referred, came to India in 1794 as an assistant surgeon and was stationed in this capacity for some years in the Sunderbans. There, influenced probably by the great French naturalists of his time, he spent his leisure in studying the fish of the deltaic creeks and estuaries. Later he was appointed to conduct a statistical survey of certain parts of Bengal and in the course of his work continued and extended these investigations and prepared an elaborate account of the fisheries, which was published many years later by Hunter in his *Statistical Account of Bengal*.[4] In 1822 after leaving India he published in Edinburgh his "Fishes of the Ganges," which is still an indispensable work of reference. Many of the original drawings of Gangetic fish prepared under his supervision are still preserved in the Asiatic Society's library in Calcutta; if published they would settle many disputed points.

After the time of Buchanan (who later assumed the name of Hamilton) a succession of zoologists worked on the Gangetic fauna in Calcutta. I have time only to mention the names of a few who are no longer living:—Benson, McClel-

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1. See Mrs. Beveridge's edition of the *Memoirs of the Emperor Babur*, fasc. p. 503 (1918); also Annandale, *Rec. Ind. Mus.* XVI, p. 122 (1919).

2. See M Crindle's *Ancient India* (London: 1901) for which I am indebted for the references to Pliny and Aelian.

3. A few very large animals are found in India and might give the impression of a gigantic fauna, but those species which have a very wide range are usually larger in temperate regions than they are in the tropics.

4. The MS is in the possession of the Asiatic Society of Bengal and would repay re-editing.

land, Blyth, Theobald, Stoliczka, Anderson and Wood Mason.[1] Of these men the first was a judge, one was a doctor, two were geologists and only three were professional naturalists. Where are the successors of the brilliant amateurs ? The work was continued by Lt.-Col. A.W. Alcock, formerly Superintendent of the Indian Museum and now Professor of Entomology in the London School of Tropical Medicine, and is still being continued by the members of the Zoological Survey of India. On recent work we cannot linger, for we must now turn from literature to facts.

From the faunistic point of view the Ganges system is divided into three parts, but the divisions are not quite the same as in the vegetation. Firstly we must distinguish the little streamlets which rush down the southern slopes of the Himalayas and unite in the valleys to form the larger tributaries; secondly we have the middle reaches, in which the Ganges and its great tributaries the Jumna and the Sone roll slowly across the great plain of northern India, and finally there are the deltaic tracts, where the main stream breaks up into innumerable tidal creeks and estuaries. Each of these regions has its own type of animal life.

In the tiny mountain streamlets there is an assemblage of very curious little animals, few if any of which could be mistaken for those from any other habitat. This is an interesting fact, for the animals of mountain torrents in Europe or North America or Japan, or even in the extreme western parts of the Himalayas, are few and very ordinary in appearance. Some of the insect larvæ are exceptionally flat and broad, or even are provided with special organs of adhesion but among the higher groups, in so far as they occur at all, there is rarely any, characteristic species. It is only as we approach the tropics, though temperature can have little to do with the matter in the cool Himalayan waters, that we find the fish and tadpoles of the little hill streams assuming peculiar forms and developing apparatus that will enable them to overcome the sudden floods and rapid rush of water to which they are exposed. So far as the fish are concerned, we find equally remarkable, but of course quite different, forms in the mountain torrents of South America,[2] but in Asia it is chiefly in the great tract of mountainous country which extends from the eastern Himalayas eastwards across China, and southwards through Burma and the Malay Peninsula into the Malay Archipelago that the young of the frog and toads seem to have conspired with the fish, to put the matter metaphorically, to produce special organs or modifications of existing organs that will enable them to cling tight in the cascades and eddies of the smallest streamlets.

Three principles are as a rule involved in their modifications, the principle of the sucker, that of producing friction in the right place and the right direction and that of reducing friction where it is undesirable. The last of these principles is illustrated mainly in the general outline of the fish and tadpoles. Almost any species from the hill-torrents of the lower eastern Himalayas will be found on examination to have very little depth, to be flat below and to have a peculiar outline in its upper profile, which rises in a gentle curve from the tip of the snout to about the middle of the body and after this point is nearly horizontal. An outline of this kind enables the animal to overcome, to a very large extent, the

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1. For further particulars see the *Centenary Review of the Asiatic Society of Bengal* (1885),and Dr. Gravely's address on the history of Indian zoology in the Proceedings of the Eighth Indian Science Congress (*Proc. A. S. B.* 1922, p. cxxxii); for more recent work my lecture " On Some Recent Advances in our Knowledge of the Freshwater Fauna of India " in *Journ. As. Soc. Bengal* (n. s.) VIII, p. 39 (1912) and reports on the Zoological Survey of India for the years 1917 to 1920 and 1920 to 1923. A bibliography of the freshwater and brackish-water fauna of India (1912-1922) by C. Dover will be published shortly in the *Journ. As. Soc. Bengal.*

2. See Regan on the Loricariidae, *Trans. Zool. Soc.* XVII, p. 191 (1904).

flow of water directed against its snout, so long as it keeps its head pointing upstream. The outline of the front part of its body offers little resistence in this position to the flow of the current, and the friction between the water and the animal is greatly reduced. Friction is also reduced in some species by the reduction or loss of scales.

Devices for the production of friction are situated on the lower surface of the animal. Their structure is often highly complicated and they are found in the fish both on the body and on the paired fins, which are expanded fan-wise in a horizontal direction, while in both fish and tadpoles they seem to be concentrated as a rule in the neighbourhood of the mouth. Dr. Sunder Lal Hora[1] of the Zoological Survey of India has recently shown that many of the structures hitherto believed to be of the nature of suckers are really friction devices. These may have the form of series of parallel plates or lamellæ studded with minute spines, or they may consist of small papillæ or ridges, but the spines, which are often quite microscopic, are always present.

The friction apparatus always works in correlation with the outline of the animal, for the water passing over its flat head presses the head down and keeps it in position, and thus enables the spines, etc., to gain a firmer grip. I must refer those who wish for further information to Dr. Hora's papers in the *Records of the Indian Museum.*[2]

We must now consider briefly the development of suckers on some of the animals of the mountain-torrents in the upper reaches of the Ganges system.

The sucker to which I refer has no resemblance to the suckers of the roots of swamp-plants. It is a device for producing a vacuum or a greatly lowered pressure of air or water on the lower side of an object and thus increasing the relative pressure on its upper side. Its usual form is that of a membrane enclosing a very small cavity which can be suddenly and greatly increased in volume without the admission of any additional air or water. Probably all the flat-bellied forms which live in mountain torrents can to some extent transform themselves into suckers by raising the central part of their lower surface while maintaining the edge in close contact with the bed or sides of the stream, but in some few forms a special organ is produced for the purpose. Such organs are found in some of the insect larvæ of rapid-running water both in the Himalayas and in other parts of the world, but it is the fish and tadpoles of the eastern Himalayas that they have perhaps received the most detailed study[3]. They are especially conspicuous in the fish of the genus *Garra* or *Discognathus* and in the larvæ of the so-called *Ranæ formosæ*. In both of these the sucker lies on the ventral surface just behind the mouth and consists of a large circular disk surrounded by a rim and by variously arranged papillæ. It is brought into action by the raising of the floor of the disk independently of the rim, which remains in close contact with the rock or stone on which the animal is lying. A cavity, which is probably very nearly a vacuum, is thus brought into existence beneath the animal, while the whole pressure of the column of water under which it is lying and of the atmosphere above is exerted on its upper surface and holds it tightly in position.

These animals of mountain streams have many other interesting features in their anatomy and physiology, but it will be impossible to discuss them further here. I would rather invite your attention to the very close resemblance between the suckers of the fish and those of the tadpoles. In the fish we find some species with the suckers much better developed than others.We have, indeed, an almost perfect gradation from species in which there is merely a flattened area behind

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1. See Hora, *Nature* CXI, p. 668 (1923).
2. Hora, *Rec. Ind. Mus.* XIX, p. 195, XXII, pp. 13, 165, XXIV, p. 31: also a paper now in the press on observations made in the Khasi Hills.
3. Annandale and Hora, *Rec. Ind. Mus.* XXIV, p. 506 (1922).

the mouth to those in which the organ is highly developed. We are dealing, therefore, with an evolutionary series, not with the sudden appearance of a new organ. The resemblance between the suckers in the two sets of animals is an excellent example of what is called parallel evolution or convergence. It cannot in the nature of things have come about owing to the common ancestry of animals so different as fish and tadpoles, but must have been evolved in direct or indirect correlation with the peculiar surroundings of the animals, either in response to some stimulus produced by the environment or by the selection of peculiarities that appeared in certain individuals by what we call chance, and were perpetuated. To me the former explanation, in so far as it is an explanation at all, seems much the more probable of the two, but it does not wholly exclude the other. It involves to some extent what is called the inheritance of acquired characters. To believe in the transmission of acquired characters was until recently heterodox, but within the last few years a strong reaction has taken place towards its acceptance—a reaction justified in my opinion by many remarkable facts well known to, but not always appreciated by naturalists. The original stimulus need not necessarily have produced a beneficial result, but if the result had not been beneficial, or at any rate harmless, the race would probably have perished.

We must now consider the animals of the middle reaches of the river, but before doing so I would point out that there is a transition between the two faunas, as is nearly always the case in nature, which does not, as the old saying goes, move by leaps. In the larger streams (comparable to the trout-streams and even the salmon-rivers of Great Britain) which occupy the deeper valleys among the mountains even at considerable altitudes, we find certain of the torren-haunting forms. We also find an invasion of species from the plains and finally among the fish at any rate, there are a few conspicuous animals which make such streams their proper home. I will only mention two, the Mahseer and the Goonch. The Mahseer, which is an assembly of allied species rather than a single form, is known to all Indian sportsmen as the chief of Indian sporting fish. It is merely a gigantic migratory Barbel sufficiently muscular to make its way upstream against the strong currents of the rivers among and at the base of the hills. The Goonch, though like the Mahseer the giant of its tribe, is in many respects the Mahseer's antithesis. It is a huge sluggish catfish which skulks in crevices amongst the rocks and thus protects itself from the force of the current. Its enormous mouth enables it to gulp down almost any prey that approaches its retreat, while the long and sensitive tentacles which surround its mouth keep it in contact with all that moves around.

Generally speaking the river-life of the plains is much less remarkable than that of the hills. Pliny's gigantic eels and his elephant-catching worms have departed into the limbo of imaginary beings. We find, however, that the animals are as a rule larger than those of the hill torrents, in which there is no room for bulky organisms. They are also more sluggish and few are very highly modified in structure. They are, in fact, very much like the animals of any other slow-flowing river. Pliny, however, was perfectly right in saying that certain of the fish were capable of migrating overland. In a tropical country in which a heavy rainfall alternates with a definite dry season, animals which live in water are subjected to very special dangers and among the fish of all countries in which such conditions occur we find a number of species that have developed special means of living out of water for considerable periods. Fish of the kind are known to all of us in India, but I do not think that most of us realize the elaborate nature of the structures which enable them to live high and dry without dying. The main difference between the breathing of an air-breathing animal and the breathing (if we may call it so) of a true aquatic animal is that the latter obtains the oxygen necessary for its existence from

water, while we obtain it from air. We are drowned in water because our lungs cannot extract oxygen from it, and similarly a fish is drowned in air because its gills cannot extract oxygen from air. Fish which are liable to partial desiccation must either have some special apparatus for storing water containing oxygen or else must learn how to breathe air. Both methods are adopted by different Gangetic fish[1].

The simplest modification is found in the murrels or snake-heads (*Ophiocephalus*), in which there is at the back of the neck a pair of large cavities lined with membrane containing many blood vessels. A considerable quantity of water can be stored in these cavities and the oxygen is extracted from it and makes its way into the blood through the thin walls of the vessels. In other fish such as the Koi (*Anabas scandens*) the membrane in the region of the gills is greatly elaborated and much folded as well as being full of blood vessels, so that there is a much greater surface through which oxygen can be extracted from the water. These structures are situated in cavities behind the head; in the Koi the membrane is supported by a bony labyrinth on which it is spread out in a thin film. In some of the catfishes and eels again, notably in the Singhi (*Saccobranchus fossilis*), a pair of sack-like organs have appeared which have practically the functions of lungs, that is to say are capable of extracting oxygen from air instead of water. Such fishes also have gills by which they get oxygen from water and they are, therefore, said to be amphipnoöus or breathing in both ways.

Comparatively few of the animals of the middle reaches of the Ganges, as I have already pointed out, are of peculiar types, but there are of course numerous very interesting and peculiar forms among them—crocodiles and turtles, fish of many kinds and sizes, water-snails and freshwater mussels, crabs and prawns, sponges and many others; but of these I can say little in the time at my disposal. I would rather draw your attention to phenomena of special interest and to animals that illustrate such phenomena. There is one feature very characteristic of the Gangetic fauna, namely the presence in it of a distinct marine element.[2] Zoologists and geologists alike believe that life originated in the sea, or at any rate that all the visible forms of life known to us are descended from marine organisms. At a very early period in geological history, however, certain forms migrated inland and, having once established themselves in rivers and lakes, often found it unnecessary, again speaking metaphorically, to undergo any great change in the course of ages. For this reason you will find that many kinds of freshwater animals are very similar all over the world, or at any rate over a very large part of it. A large number of the water-snails of Calcutta, for instance, have very close relatives among those of the British Isles, while in the valley of Kashmir many are actually identical with British species. The ancestors of all such forms came from the sea millions of years ago and their relatives which did not migrate inland have long since perished and disappeared. Strictly speaking, all freshwater animals are, therefore, of marine origin, but the marine element in the Gangetic fauna to which I have referred is something different. Its members are so closely related to animals which still live in the sea that we need have no doubt in claiming that their ancestors came from the sea at a not very distant geological date. To the most conspicuous member of the little group of marine animals which live in the Ganges above tidal influence I have already referred more than once. It is one of the most conspicuous animals of the river and was possible mentioned by Asoka in the 3rd century B.C. and certainly described by Pliny

1. Good figures will be found in the volume on the fishes in the Cambridge Natural History.

2. For an account of this element and of the brackish water fauna see Annandale, *Bijd. t. d. Dierkunde Nat. Atr. Mag.* (Max Weber Complimentary Volume), p. 143 (1922).

in the 1st century A.D., by Alberuni in the eleventh century and by Babur some five hundred years later. It is the Gangetic Porpoise now known to science as *Platanista gangetica*.

The terms porpoise, dolphin and whale have no very precise scientific meaning. Porpoises, dolphins and whales are all members of the group Cetacea, in which there are many species and genera which it would be difficult to place without doubt in any one of the three categories. Generally speaking porpoises and dolphins are much smaller animals than whales, and frequently the name porpoise is given to forms with a short rounded head while the so-called dolphins have a long and slender snout. The Gangetic Porpoise is small for a Cetacean (not more than 12 feet in length), but has an even longer and narrower snout than the true Dolphin. I will return to its physical peculiarities in a moment, but the most interesting fact about its life is that it lives in both the Indus and the Ganges and never goes to sea. The vast majority of the Cetacea are marine animals. A few, such as *Orcaella brevirostris*, which makes its way up the Irrawaddy for nine hundred miles and is also found in the lower regions of the Ganges, can live in both salt and fresh water, while a very small number of species have established themselves like *Platanista* inland in rivers or lakes. Such species are found outside India only in the great rivers and lakes of China and of South America. They are all more or less closely related to *Platanista* to which a species from the Tongting Lake in the centre of China has recently been shown to be very closely allied[1]. No similar species are known from the sea at the present day but the remains of allied forms occur in the marine tertiary deposits of different parts of the world. The Gangetic Porpoise is, therefore, a relic of a former age which has maintained its existence by forsaking the sea, where its race was about to perish for some unknown reason. Its relatives in China and South America have had a similar fate. The fact that this animal is found both in the Indus and the Ganges points to some former connection between the two rivers at a period when their physiography was very different from what it is now; but this connection may have existed, and in my opinion probably did exist, before the birth of either the Ganges or the Indus as a great river. Not improbably the genus first appeared in great lagoons or gulfs in what is now the Gangetic trough at a period when the present relations between land and sea had not yet been established in northern India.

In spite of its ancient ancestry *Platanista* is highly modified in certain respects, particularly in its long sensitive snout and in being practically blind. In these respects it is modified for life in very muddy water and is adapted to obtain its food, which consists of prawns, molluscs, etc., from the soft mud at the bottom of a sluggish river.

The Gangetic Porpoise is not the only animal of comparatively recent marine origin found in the Ganges above the influence of the tides, for at least two remarkable genera of bivalve molluscs share this peculiarity with it. They belong to the two families of the arc-shells and the razor-shells. The former are so called from a somewhat fanciful resemblance between the shells and Noah's Ark while the latter have their name from their long band-shaped outline and the sharp edges of the shells. In most parts of the world the animals of both families are exclusively marine, but in the rivers which run into the Bay of Bengal, and also in those which enter the Gulf of Siam, members of the two genera, which are called *Scaphula* and *Novaculina*[2] have made themselves at home in fresh water The shells of both genera are much smaller than those of most of their marine relatives and their structure is comparatively simple. Neither genus has any

[1] See Hinton & Pycraft on *Liphotes*, *Ann. Mag. Nat. Hist.* (9) X, p. 232 (1922).
[1] Ekendranath Ghosh, *Proc. Zool. Soc. London* II, p. 1139 (1922).
[2] *Idem*, *Rec. Ind. Mus.* XIX, p. 64 (1920).

very close relations now living in the sea and we know nothing about their fossil ancestors. The fact, however, that the animals are simple in structure as compared with all the marine members of their respective families shows that they are probably very ancient and that they, like *Platanists*, left the sea as their race was dying. They were enabled to do so by their peculiar physiological adaptability, for they survived the change from salt water to fresh—a change which implies both a difference in the specific gravity and also in the chemical composition of the medium in which the animals lived. It is as though a man were to accustom himself to live permanently in tobacco-smoke instead of air.

This physiological adaptability[1] is one of the most peculiar features of the animals which live in the creeks and estuaries of the Gangetic delta. To these animals we must now turn, leaving almost everything unsaid about the fauna of the middle reaches of the river. With them as with the fauna of the hill-streams the transition is gradual. We find many species which can live with equal comfort in the middle reaches and in the deltaic tracts; we find some that are characteristic of the upper waters of the delta, a few migrate periodically either from the sea or from the creeks for a considerable distance upstream, while a still smaller company takes the opposite course, descending from the middle reaches to the lower at the breeding season. Most noteworthy of those forms which come up the river from the sea is the Hilsa, one of our best known food-fishes. Like the salmon of Europe and North America it is a marine fish which ascends rivers to breed. Certain prawns also come up into the delta for the same purpose, while others go downstream into the sea from the lower reaches of the river. Animals which go upstream to breed are called anadromous, those which go downstream catadromous.

The great majority of the animals of the deltaic creeks and estuaries are, however, what is called euryhaline. That is to say they are (within certain limits) indifferent to the amount of salt dissolved in the water in which they live. Most of them are of marine origin and comparatively few can endure pure fresh water for any length of time. This feature is well illustrated by a little jellyfish called *Campanulina ceylonensis*[2], which was originally described from the sea off Ceylon but has also been found in brackish water in both India and Siam. When the water in the Belgatchia canal on the outskirts of Calcutta sinks very low, as it does as a rule at some date in April every year, lock-gates are opened which admit the brackish water of the Matlah river. With the water come swarms of this little jellyfish, and they lay their eggs in the canal. From the egg arises a simple larval form called a planula and this turns into a minute hydroid, which is fixed to bricks and mooring-posts. The hydroid again gives rise to a second brood of jellyfish by means of budding and the alternate generations of medusa and hydroid are rapidly perpetuated for some months, until the water is thick with litte medusæ and the submerged bricks of every ghat and the surface of every post are covered with the hydroid. Then come the rains and the water grows gradually fresh. When its specific gravity falls below a certain point both jellyfish and hydroid are killed and the species disappears from the canal, until it is re-admitted with the inflowing water in the following April.

These facts illustrate the manner in which the animals of the estuaries are attempting to establish themselves inland. I may give another and even more striking instance, that of the little crab *Varuna litterata*[3]. This animal is still more tolerant of changes in salinity than the jellyfish and its hydroid, for it can

1. Redeke's recent attempt to provide a more exact classification of brackish-water animals hardly appli s to those of Indian waters, where conditions are much more complicated than in Europe. See Redeke, *Bigid. t. d. Dierkunde Nat. arl. Mag.* (Weber complimentary volume), p. 329 (1922.)

2. See Lloyd & Annandale, *Rec. Ind. Mus.* XII, p. 49 (1916), and Annandale *Mem. As. Soc. Bengal* VI, p. 112 (1919).

3. See Kemp, *Mem. Ind. Mus.* V, p. 233 (1915).

live equally well in the open sea and in pure fresh water, but its real home is in the estuaries. Every year a double invasion of the Varuna crab takes place in the neighbourhood of Calcutta. The crab breeds a little before the beginning of the rains. For some time the female carries her eggs tucked up under her tail, but the eggs, unlike those of the true river crabs, give rise to a little larva different from its parents, though not so different as the caterpillar is from the butterfly. The larvæ are produced in countless millions at the edge of the Hughli below Calcutta and in every creek of the Sunderbans. Their natural instinct leads them upstream: they swarm into every ditch of fresh or brackish water to which they can gain access, and not infrequently they block up pipes carrying water from the river.

As soon as the parent crabs have got rid of their family, to which as a matter of fact they pay no regard whatsoever, they too proceed to migrate inland. They crawl and swim into ditches and water-courses; they proceed along the gutters of the streets of Calcutta and, leaving the water, walk amongst the damp herbage of gardens and jungles and so penetrate into isolated ponds and tanks. They frequently appear in the tank in the Museum compound and I have seen one surrounded by a flock of crows in the middle of the lawn of the United Service Club.

And yet, in spite of this double migration inland, in spite of its tolerance of fresh water, the Varuna crab never establishes itself as a permanent denizen of inland waters in the Gangetic delta. From the Calcutta tanks it disappears rapidly and can as a rule be found only in a few of the ponds in the immediate neighbourhood of brackish water, in places such as Chingrihatta. Why is this? Apparently because it cannot compete with the true river crabs which are already established in fresh water. It has appeared too late on the scene.

A little lower down in the delta a remarkable phenomenon has been observed by Dr. S. W. Kemp[1]. He found in the Matlah river, which is now mere creek connecting the remains of the once extensive Salt Lakes on the outskirts of Calcutta with the sea, that the fish and prawns and also some of the other animals were curiously similar in general appearance to those which he had seen dredged from great depths in the sea. Deep-sea animals have many peculiarities, the most conspicuous of which are their colouration, the condition of their eyes and the production of long thread-like organs of touch. In all these respects a large number of the Matlah forms show a strange resemblance to deep-sea species. Like these they are mostly either of a dull translucent white colour, like the glass of which lamp-shades are made, or when bright pigment is present in them it is usually of a deep pink or red shade, which is also common in the abyssal fauna. Most deep-sea fishes either have very large eyes to enable them to make use of any rays of light that may be present at great depths, or else have their eyes much reduced; sometimes they are totally blind. Most of the fish of the Matlah river have very small eyes. Further, both they and certain of the prawns that live with them are provided with very long and slender organs of touch. In the fish (for example the well-known Topsi or mangoe fish) it is the rays of the anterior paired fins which are produced into long filaments. In at least one kind of prawn common in the Gangetic delta, however, the legs have lost their function as organs of progression and have become tremendously long threads which trail round the animal as it swims by means of the little paddle-like organs beneath its tail. Just so certain deep-sea prawns have produced thin thread-like legs, but it is interesting to observe that in the abyssal forms the lengthening of the leg has taken place in quite a different way from that in which it has been brought about in the estuarine species and that different parts of limbs are modified in the two forms.

[1] Kemp, *Rec. Ind. Mus.* XIII, p. 233 (1917).

This resemblance between a number of the animals of a small comparatively shallow deltaic creek and those of the deeper parts of all seas is a striking phenomenon which cannot be gainsaid by any observer who has seen the animals in their fresh state; but what does it mean? Most of the forms from the creek differ greatly in their general structure from deep-sea forms[1]. Why should unrelated animals from such different habitats resemble one another outwardly; too many different kinds of animals are involved for us to call in mere chance as an explanation. We cannot of course say what is the ultimate cause of this convergence, but there are only two physical features which the deep sea and the creeks of the Gangetic delta have in common, *viz.*, a very soft oozy bottom and a low visibility, due in one case to absorption of the rays of light as they penetrate through thick layers of water and in the other to the fact that the water is full of minute particles of suspended silt which produce in it much the same effect as fog or smoke does in the air. We can hardly doubt that the resemblance between the two faunas is in some way associated with this resemblance in the physical characters of their environment. Here again we have an example of parallel evolution, but of a different kind, for here the convergent forms do not live together but in very different surroundings, which have only certain factors in common. Evolution has been at work on parallel or rather convergent lines and some response to environment on the part of ancestral forms is plainly indicated.

I must now bring my lecture to a close. I have not attempted the impossible task of summarizing the multitudinous aspects of the Gangetic fauna in the space of an hour. What I have tried rather to do is to bring to your notice a few of these aspects, and particularly to say something of the wonderful manner in which some of the animals are modified to suit their surroundings in different parts of the river-system. Another point of special interest on which I have laid stress is the fact that animals to be successful in the race of life cannot trust merely to the modifications that come about in their bodies without their own volition. With the Varuna Crab and the Ceylon Medusa individual effort is necessary to conquer new territories, and even if the conquest is not permanent a slight change in conditions may make it permanent some day, if only the effort be persistent from generation to generation. As it is with these little water beasts, so it is also with mankind. Success depends on effort.

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[1] The only exception is the "Bombay Duck (*Harpodon nehereus*) which is loosely related to deep-sea forms but is itself at home in estuaries.